

## WERF Research on the Treatment and Management of Residuals and Biosolids

### Highlights:

- Almost a third of WERF's research projects have focused on the treatment and management of residuals and biosolids. This includes 45 completed plus 17 ongoing and new research projects/challenges valued at over \$20 million.
- Two of the six program areas in WERF's new PDR (Program Directed Research) process which was launched in 2005 will continue work in this area – they include Solids Treatment, Residuals & Reuse and Wastewater Treatment & Reuse.
- Over 25% of the recently identified key Subscriber challenges are also related to residuals and biosolids.
- Biosolids TCR (Targeted Collaborative Research) program set up by WERF to fund research on key biosolids related issues that were identified in the WERF-EPA Biosolids Research Summit (2003) and by the TCR funding partners.

No.	Project Number and Project Title	Research Objectives
1	90-4, Innovative Process Assessment: Sludge Processing, Disposal, and Reuse	Provides an assessment of diverse research/development projects regarding the treatment and disposal of biosolids.
2	91-ISP-1, Evaluating and Measuring Biosolids Incinerator Emissions (Product No. D93006)	Developed a database on incinerator emission characteristics; users determine performance evaluation for various airborne contaminant control options (including hydrocarbons).
3	91-ISP-4, Document Long Term Experience of Biosolids Land Application Programs (Product No. D0015)	Provides information on the beneficial use of biosolids in land application programs.
4	91-ISP-5, Polymer Characterization and Control in Biosolids Management (Product No. D43007)	Provides information on optimal usage of chemical conditioners for biosolids dewatering. Assesses automatic polymer feed equipment. Provides a formal protocol for making decisions on selecting polymers and estimating dosing rates.
5	91-ISP-5A, Guidance Manual for Polymer Selection in Wastewater Treatment Plants (Companion report to project above) (Product No. D0013)	Aids wastewater chemists, managers, and operators in the selection of polymers. Systematic processes for polymer selection are divided into modules for each type of polymer application with step-by-step guidance.
6	92-PUM-1C0, Long-Term Fate of Land Applied Wastewater Materials	A collaborative program project that examines the long term effects of land application of biosolids products and evaluates the effects of using various forms of materials on land sites, including compost, pelletized products and liquid applications.
7	94-REM-1, Defining Biosolids Stability: A Basis for Public and Regulatory Acceptance (Product No. D72002)	Provides information on biosolids stability criteria and recommends definitions for stability for various biosolids processes and products.

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8	94-REM-2, Analysis and Fate of Polymers in Wastewater Treatment (Product No. D00301)	Addresses the impact and fate of polymers used as flocculant agents in wastewater treatment. Evaluates when polymer release to the environment may be harmful. Examines analytical methods to detect polymer.
9	95-REM-3, Understanding Fate, Transport, Bioavailability and Cycling of Metals (Molybdenum) in Land Applied Biosolids (Product No. D93017)	Improves understanding of risks and the pathways associated with metal uptake (focusing on molybdenum) in grazing animals. Enhances scientific knowledge base and provides information relative to EPA's Part 503 regulations on molybdenum.
10	96-CTS-5, Benchmarking Wastewater Treatment Plant Operations – Collection, Treatment, and Biosolids Management (Product No. D73001)	Derives performance standards for wastewater treatment operators to help focus their efforts, improve operations, and reduce costs. Highlights approaches, processes, and results that have been used by others to accomplish these objectives.
11	96-REM-1, Biosolids Management: Assessment of Innovative Processes (Product No. D83004)	Identifies and reports on the development, status and cost effectiveness more than 110 innovative biosolids processing and management technologies.
12	96-REM-2, Watershed Effects of Biosolids Land Application: Literature Review (Product No. D93003)	Assesses available information (more than 1400 references spanning 100 years) on the uses and impacts of biosolids in watersheds.
13	97-REM-2, Pathogen Destruction Efficiency in High Temperature Digestion	Compiles information available worldwide on high temperature digestion studies. Will develop practical and economical high temperature (mesophilic/thermophilic) digestion protocols to yield Class A biosolids products and augment existing processes to further reduce pathogens.
14	97-REM-3, Estimating Plant-Available Nitrogen in Biosolids (Product No. D00307)	Practical guidance for biosolids managers and regulatory agencies in using biosolids to benefit crop growth, and in minimizing the potential for nitrogen to migrate to groundwater or cause surface water pollution.
15	97-REM-4, Investigating the Effects of Electrical Arc Pretreatment of Biosolids (Product No. D00314)	Investigates the feasibility of electrical arc pretreatment of biosolids as a potential innovative biosolids dewatering process prior to chemical conditioning and dewatering. Addresses fundamental and applied aspects of its operation.
16	97-REM-5, Assessing Bioavailability of Metals in Biosolid-Amended Soils: Root Exudates and their Effects on Solubility of Metals	Exploring phenomena that control the fate of metals in biosolids and soil mixtures, and impacts on ecological and human health. Will improve technical basis of 503 Rule, thereby enhancing its acceptability within the scientific community and improving public confidence.

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17	98-CTS-2, Use of Novel Techniques to Quantify Phenotypes in Biological Treatment Processes	Will use novel techniques to identify specific phenotypes, and have relevance to municipal and industrial wastewater treatment as well as the treatment of biosolids.
18	98-REM-1 (Phase 1), A Dynamic Model to Assess Microbial Health Risks Associated with Beneficial Uses of Biosolids	The first phase developed an assessment framework for microbial exposures associated with beneficial biosolids reuse, and a streamlined protocol to assess risks from various exposure pathways.
19	99-PUM-1, Evaluating Risks and Benefits of Soil Amendments Used in Agriculture	Determines the risks and benefits, advantages and potential disadvantages associated with the use of a variety of soil amendments in comparison to chemical fertilizers. Provides information in determining which soil amendment can be used in or for a specific soil, crop, or climatic condition.
20	99-PUM-2T, Characterizing the Forms, Solubilities, Bioavailabilities and Mineralization Rates of Phosphorus in Biosolids, Commercial Fertilizers and Animal Manures (Phase 1) (PDF available)	Phase I characterized the forms and solubilities of phosphorus in a variety of biosolids products and in biosolids-soils matrices. Phase II will further define this work
21	99-PUM-3, Developing Protocols for Measuring Biosolids Stability	Develops standard, detailed protocols for conducting tests that are commonly used to assess stability in the associated biosolids/products.
22	99-PUM-5T, Manual of Good Practice for Biosolids (Product available from the NBP website: <a href="http://biosolids.policy.net/emsguide/manual/goodpractmanual.vtml">http://biosolids.policy.net/emsguide/manual/goodpractmanual.vtml</a> )	A targeted collaborative project that developed an online resource document on the issues to be considered when designing and implementing a biosolids management program. [Managed by WERF for the National Biosolids Partnership.]
23	99-PUM-6-ET, Evaluating the Use of Near-Infrared Spectroscopy for the Analysis of Biosolids Constituents (Product No. D00306)	An emerging technology project that evaluated the feasibility of applying near-infrared spectroscopy (NIRS), widely used in commercial and industrial applications, to analyze nutrient and heavy metal concentrations in biosolids and receiving soils.
24	98-REM-3, Thickening and Dewatering Processes: How to Evaluate and Implement an Automation Package (Product No. D13006)	Evaluates state of current practices, screens and field tests selected automation processes. Provides information to improve dewatering operations to cut the cost of dewatering biosolids in POTWs and in downstream operations.
25	00-CTS-8, Membrane Technology: Feasibility of Solid/Liquid Separation in Wastewater Treatment	Provides a comprehensive assessment of membrane applications and identifies a method to evaluate the use of membrane technologies for specific treatment applications. Results from this research will allow for a direct comparison of membrane technologies with more conventional methods of solid/liquid separation.

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26	00-CTS-10T, Minimizing Biomass Production from Biological Treatment	Will identify and evaluate methods to reduce biological solids in aerated biological reactors. It will determine whether cost savings can practically be realized by reducing the ultimate amount of waste requiring treatment and disposal.
27	00-HHE-5T (Phase I) Identifying and Controlling Municipal Wastewater Odor Environment – Literature Review	The primary objective is to evaluate the state of knowledge and science about odors and odor control for all stages of treatment and disposal of wastewater and residuals. It provides a basis from which to begin a multi-phase process to develop efficient, effective odor control technologies at all stages of wastewater treatment and disposal. Phase 1 involves critical reviews and syntheses of published information (includes conventional and grey literature), findings from recent and upcoming odors-related workshops, as well as electronic databases.
28	00-HHE-5T (Phase II), Identifying and Controlling Odor in the Municipal Wastewater Environment Phase II: Impacts of In-Plant Parameters on Biosolids Odor Quality	Phase 2 will collect objective data to demonstrate the influence of anaerobic digestion system design and operating parameters on the odor quality of the final product. Biosolids odor emissions will be measured before and after anaerobic digestion and operations and treatment parameters will be measured to determine the influence of these parameters on biosolids odor quality. A total of 10 POTWS are involved in the Phase 2 research effort.
29	00-HHE-5T (HEA), Identifying and Controlling Municipal Wastewater Odor Environment – Health Effects Addendum	The overall objective was to identify the research gaps and needs through a review of appropriate literature and to prioritize the future direction of research on health effects associated with POTW biosolids odors.
30	00-PUM-5, Biosolids: Understanding Public Perception and Participation	Lessons learned from successful and unsuccessful biosolids recycling programs will be shared to provide guidance in incorporating stakeholder priorities.
31	00-PUM-7, Development of a Cost Determination Protocol for Use in Benchmarking Biosolids Management Programs	Developed a protocol to identify and quantify direct and indirect costs associated with management of biosolids for all reuse and disposal options. The protocol was tested and refined at several sites that represent wide range of biosolids management options in diverse geographic areas. Should help utility managers evaluate the cost of biosolids management programs on a consistent basis with other agencies.
32	01-CTS-32-ET, A New Tool for Measuring Biosolids Floc Strength	Established a standard method and set of procedures for measuring floc strength. Will aid in understanding fundamentals of conditioning and enhance full scale dewatering

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33	02-CTS-8-P Advanced Biosolids Flow-Through Thermophilic Treatment (BFT3) Demonstration Project	Evaluated the BFT3 process for retrofitting existing digestion systems to upgrade them from Class B to Class A. WERF provided peer review of the protocols definition, experimental testing for health risk assessment of microbial contaminants, and full-scale start-up.
34	02-HHE-1-CO, Analytical Method for Endocrine Disruptors in Sewage Sludge	Will solidify methods for extracting steroidal hormones from biosolids.
35	03-HHE-1, WERF/EPA Biosolids Research Summit	Multi-stakeholder workshop that developed a research agenda to address scientific issues related to the land application of biosolids.
36	95-REM-2 Producing Class A Biosolids with Low-Cost, Low-Technology Treatment Processes	Class A biosolids have been and are now being produced by low-cost, low-technology biosolids treatment processes including lagoon storage, air drying, and cake storage. This project reviewed the available literature and municipal agency data about these processes.
37	00-PUM-6, A Safety Assessment Tool for Land Application of Biosolids	Will develop a series of toxicity bioassay tests that will provide practitioners with a way to address citizen concerns regarding the human health and environmental impacts of biosolids reuse.
38	01-CTS-1, Mechanisms of Conditioning, Thickening and Dewatering	Will improve understanding of the nature of flocs and the specific chemical interactions that alter floc properties. Results could lead to better selection of conditioning chemicals, help to reduce chemical costs and/or lead to improved dewatering techniques.
39	03-CTS-13T, Examination of Reactivation of Fecal Coliforms in Anaerobically Digested Biosolids	Will look at the phenomenon of reactivation of pathogens through the digestion process. Will demonstrate that pathogens exist in a viable-but-non-culturable state through the digestion process but are induced to become culturable due to the presence of a substrate in the dewatering process, which allows for rapid growth in the final cake material.
40	98-REM-1A (Phase II), A Dynamic Model to Assess Microbial Health Risks Associated with Beneficial Uses of Biosolids	The second phase will apply the framework developed in Phase I to characterize risk associated with real-world biosolid application scenarios. It will also provide a Research Digest aimed at a more general audience to emphasize the practical aspects of the findings.
41	99-HHE-3, Control of Human Parasites in Municipal Biosolids	Screens, identifies, and selects an appropriate surrogate human parasite(s), in lieu of helminth ova, and develops protocols to recover, detect, and measure surrogate organism(s) for municipal wastewater biosolids.

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42	01-HHE-3, Assessing the Fate of Emerging Pathogens in Biosolids	Will detect and follow the fate of emerging pathogens in biosolids from the treatment process through land application until they are undetectable. Will help address public health concerns regarding land application of biosolids.
43	02-CTS-3, Innovative Technologies to Reduce Water Content of Dewatered Sludges	Will evaluate methods to improve water removal from dewatered cakes, including innovative equipment, new additives, additive or conditioning agent combinations, physical modifications, or a combination of these or other approaches.
44	02-PUM-1, Quantification of Airborne Biological Contaminants Associated with Land Applied Biosolids	Also addresses concerns raised by NRC's recent report on biosolids. Will provide fundamental data to assess the potential release and exposure to airborne biological contaminants from land application of Class B biosolids by analyzing current health-impact literature. Data produced will provide basis for a comprehensive, full-scale analytical investigation.
45	04-CTS-2, Cost/Benefit Analysis of Management Options for Sludge/ Biosolids	Will develop a method for evaluating the costs and benefits of various sludge/biosolids disposal and beneficial use options that provides utility and industry managers with the information necessary to make a decision on which option to use. This information can also be shared with the general public to help explain the disposal or beneficial use options made by the utilities.
46	99-PUM-2T (Phase II), Characterizing the Forms, Solubilities, Bioavailabilities and Mineralization Rates of Phosphorus in Biosolids, Commercial Fertilizers and Animal Manures	Phase II research will confirm and expand Phase I findings on the fate of phosphorus added to soil from biosolids and manures and will improve our ability to use these amendments for environmentally sound crop production.
47	01-CTS-18-UR, Cost-Effective Energy Recovery From Anaerobically Treated Wastewater Solids	Will identify cost-effective alternatives for energy recovery from solids treatment (anaerobic) based on key factors such as energy costs, regulatory conditions, plant capacity, social values, and more.
48	01-CTS-19-UR, Effects of Biosolids Properties on Membrane Bioreactors (MBRs) and Solids Processing	Will investigate the effects of biosolids characteristics on membrane performance and solids processing. This will help define the operating limits of MBRs in municipal wastewater treatment and improve understanding of the behavior of solids to be processed.

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49	02-HHE-2, Biosolids Sample Processing for Analyses of Pathogens	Addresses concerns raised by NRC's recent report on biosolids. Will develop sample preparation methods for use with molecular detection techniques such as microarray analysis, quantitative PCR, fiber-optic biosensors, and other new technologies. Will help address public concern over land-applied biosolids by measuring the presence and fate of pathogens.
50	03-CTS-9, Biosolids Processing Modifications for Cake Odor Reduction	Will build on and enhance an existing process, anaerobic biosolids digestion, to produce lower-odor biosolids. Equipment or process vendors may be invited to demonstrate their processes full-scale at one or two plants, while researchers collect and analyze data and compares results. Builds upon work conducted in Identifying and Controlling Municipal Wastewater Odors (00-HHE-5T).
51	03-HHE-2, Pathogen Risk Indicators for Wastewater and Biosolids	Will compare the accuracy, advantages, and disadvantages of existing indicator organisms with proposed indicators in wastewater and biosolids. If successful, alternative organisms will provide better indicators of public health impacts, more accurate tools for setting appropriate standards, and more effective monitoring of water and biosolids, leading to increased confidence in the quality of effluent and residuals.
52	04-CTS-3T (Phase II), Fecal and Pathogen Regrowth/Reactivation From Centrifugation of Anaerobically Digested Sludges	Will examine the extent that organisms may be entering the VNC state during digestion and the conditions that cause their reactivation. Follow-up to 03-CTS-13T study.
53	06-HHE-5PP, Methodology for Implementing a Rapid Incident Response Mechanism	This project was the highest ranked priority at the 2003 Biosolids Research Summit. The first phase of the project will develop a protocol to be used in conjunction with established public health investigation procedures and implemented through the existing network of public health organizations.
54	04-CTS-7T, Minimizing Mercury Emissions from Biosolids Incinerators	Will quantify mercury emissions from representative biosolids incinerators located in the United States. Will establish test protocols that POTWs that practice incineration can use to accurately determine the fate of the mercury that enters their plants. Will identify practices and control technologies to cost-effectively reduce mercury emissions from biosolids incinerators.

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55	04-HHE-6, Fate of Estrogenic Compounds During Municipal Sludge Stabilization and Dewatering	Will investigate the fate of known estrogenic compounds and total estrogenic activity in solids derived from wastewater treatment, in processes commonly used to stabilize, disinfect and dewater municipal wastewater treatment sludges.
56	04-HHE-7, An Investigation into Biosolids Sampling and Handling Methods for USEPA-Approved Microbial Detection Techniques	Will develop scientifically defensible methods for collecting and handling representative samples for microbial analysis from biosolids matrices with the greatest potential impact to public health (liquid, cake, compost).
57	05-CTS-3, Evaluation of Processes to Reduce Activated Sludge Solids Generation and Disposal	Develop and demonstrate an evaluation methodology that will be used to independently assess the effectiveness of at least one selected commercially available process. This tool can be used by industrial and municipal wastewater treatment facility owners and operators to technically and economically evaluate processes that can reduce waste activated sludge quantities
58	05-CTS-2T, Evaluation of BMPs for Sustainable Groundwater Protection at Biosolids Land Application Sites	Initial focus will be to develop a protocol to evaluate land application sites to assure that groundwater contamination is not occurring and effectively communicate groundwater protection safeguards with the public.
59	04-CTS-3T (Phase III), Verifying the Occurrence of Reactivation / Regrowth of Microbes in Biosolids Following Digestion and Dewatering	The focus of this project will be to determine the extent that reactivation / regrowth of pathogens in digested and dewatered biosolids, which has been the focus of two previous studies, is or is not occurring.
60	06-OWSO-1, Optimization of Wastewater and Solids Operations	This integrated challenge includes the following 2 initial Solids challenges and 1 initial Wastewater challenge. It features a holistic look at wastewater and solids operations at wastewater facilities: <ul style="list-style-type: none"> <li>• Develop cost-effective methods to minimize the volume and quantity of solids generated, without sacrificing product value and quality</li> <li>• Identify new resource recovery opportunities for biosolids</li> <li>• Develop tools for cost-effective management of energy use in wastewater operations</li> </ul>
61	06-SRSK-1, Applying Advances in Pathogen Risk Assessment to Land Application of Biosolids and Communicating the Results	The initial focus of this Research Challenge is implementing user-friendly interfaces to input data into available pathogen risk assessment methodologies developed for land application of biosolids, and applying them in a variety of situations. Special emphasis will be given to developing effective risk communication tools. Implementation of this research will incorporate “public partnering” protocols developed in prior WERF research.



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62	Eliminate or Reduce Odors Associated with Biosolids	This Research Challenge will build upon the Phase III WERF biosolids odors research project to be completed by the end of 2007.

Information current as of November 7, 2007